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(54) METHOD FOR DYNAMICALLY SELECTING ALLOCATION OF RANDOM ACCESS CHANNELS IN A COMMUNICATION SYSTEM

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(52) **U.S. Cl.** **709/236**; 455/464; 370/280; 709/226

(58) **Field of Search** 709/236, 227, 709/235; 340/825.01, 825.02, 825.03, 825.04; 370/264, 280, 915, 329, 337, 336; 455/450, 464, 224

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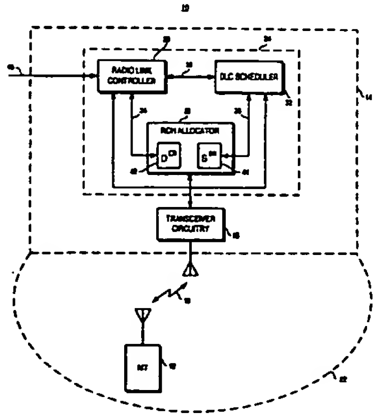
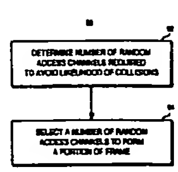
(57) **ABSTRACT**

Apparatus, and an associated method, by which to select the number of random access channels to form a portion of a frame in a frame-formatted communication system. The number of random access channels allocated to form a portion of a frame is made responsive to quantitative determination of the likely need to communicate thereupon during the frame. In one implementation, selection is made of the number of random access channels to form portions of a frame defined in a HIPERLAN/2 system.

21 Claims, 2 Drawing Sheets





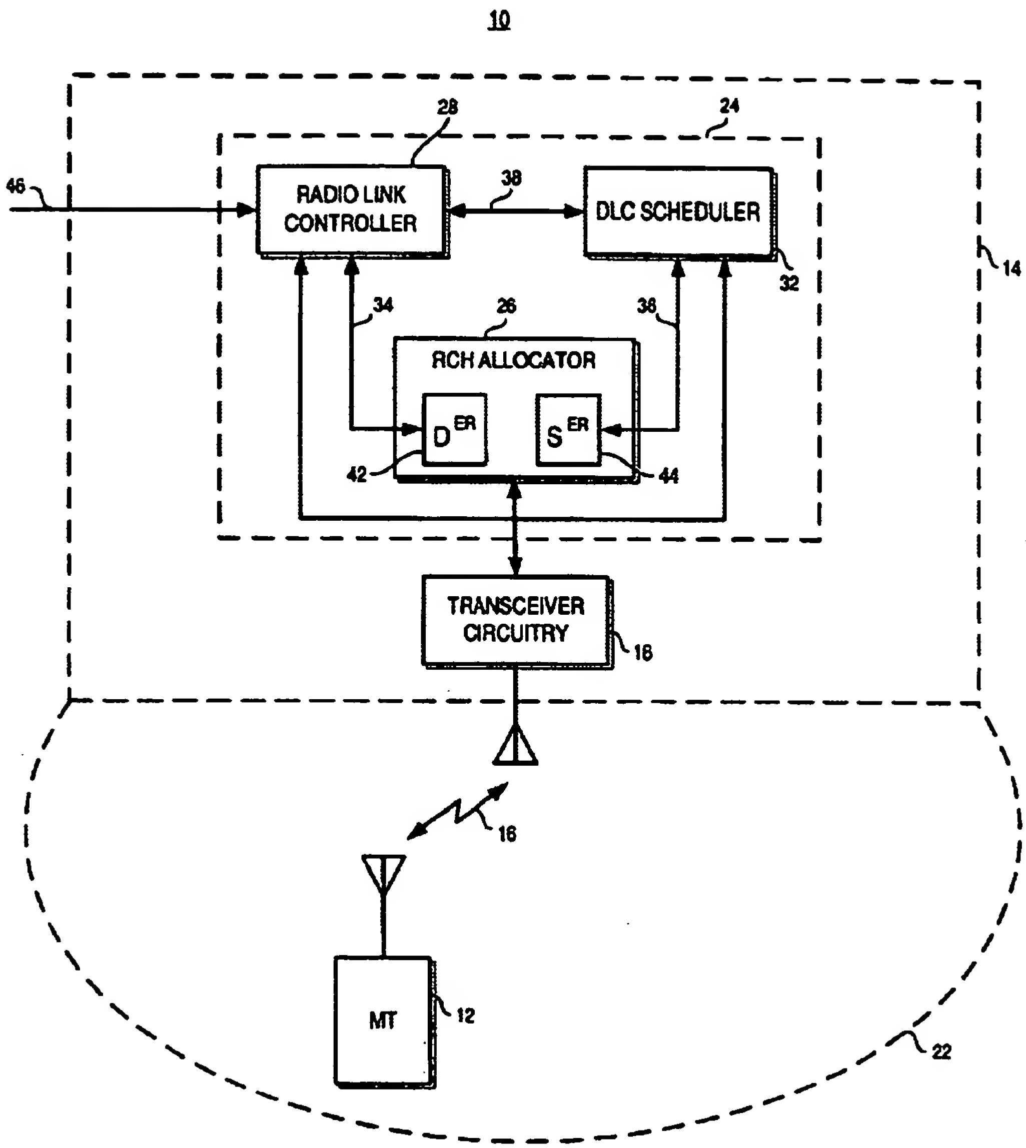

10
28
24
46
RADIO LINK CONTROLLER
38
DLC SCHEDULER
14
32
34
26
36
RCH ALLOCATOR
D^{ER}
S^{ER}
42
44
TRANSCEIVER CIRCUITRY
18
16
MT
12
22

FIG. 1

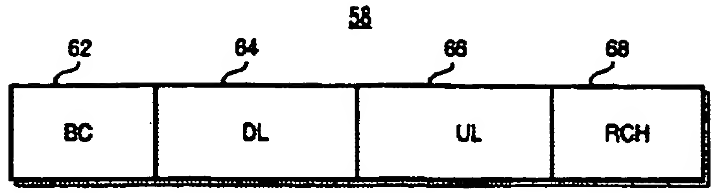


FIG. 2

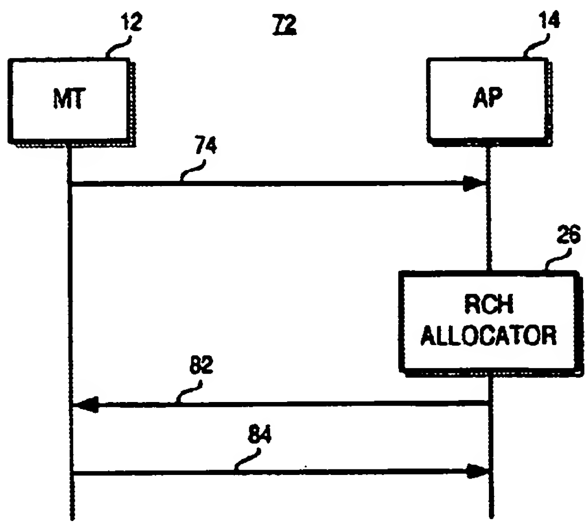


FIG. 3

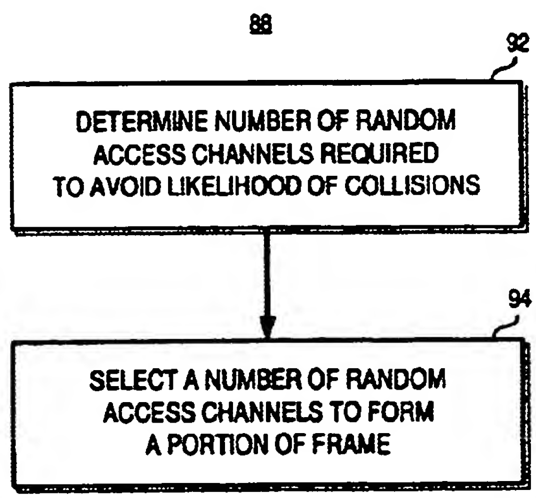


FIG. 4

METHOD FOR DYNAMICALLY SELECTING ALLOCATION OF RANDOM ACCESS CHANNELS IN A COMMUNICATION SYSTEM

The present invention relates generally to channel allocation in a frame-formatted, time-division, communication system, such as a radio LAN (local area network) operable to the proposed HYPERLAN/2 standard. More particularly, the present invention relates to apparatus, and an associated method, by which to allocate radio channels in a frame defined in the communication system. Allocations are made dynamically, e.g., on a frame-by-frame basis, responsive to determinations of anticipated need to communicate upon the random access channels during the frame.

BACKGROUND OF THE INVENTION

A communication system is operable to communicate information between a sending station and a receiving station by way of communication channel. A radio communication system is a communication system in which the communication channel by which information is communicated between the sending and receiving stations is formed upon a portion of the electromagnetic spectrum. Such a communication channel is sometimes referred to as a radio channel. Because a radio channel does not require a wireline connection for its formation, a radio communication system inherently permits an increase in communication mobility relative to communication systems which require wired connections to form a communication channel.

Bandwidth limitations, which limit the communication capacity of many types of communication systems, are particularly limiting in many radio communication systems. Such bandwidth limitations in a radio communication system are typically due to limitations on the amount of the electromagnetic spectrum allocable to the radio communication system. Such bandwidth limitation limits the increase of communication capacity of a radio communication system. As a result, sometimes, the only manner by which to increase the communication capacity of the system is to increase the efficiency by which the allocated spectrum is utilized. Other types of communication systems similarly can exhibit a communication capacity increase as a result of increase in the efficiency by which the communication channels formed between sending and receiving stations of such systems are utilized.

Digital communication techniques, for instance, provide a manner by which to increase the efficiency by which to effectuate communications upon communication channels of a communication system. Implementation of digital communication techniques in a radio communication system is particularly advantageous due to the particular need to efficiently utilize the spectrum allocated to such a system.

Information which is to be communicated in a communication system which utilizes digital communication techniques is typically digitized into discrete, digital bits. Groups of the digital bits are sometimes formatted into packets, referred to as data packets. The data packets are communicated by the sending station, either individually or in groups, at discrete intervals to a receiving station. Once received at the receiving station, the packets of data are concatenated together to recreate the informational content contained therein.

Because packets of data can be communicated at discrete intervals, the communication channel upon which the packet is transmitted need not be dedicated to a single sending-

receiving station pair. Instead, a shared communication channel can be used to communicate packets of data communicated between a plurality of sending-receiving station pairs. Because of the shared nature of the shared channel, improved communication capacity is possible.

Packet data communications are effectuated, for instance, in conventional LANs (local area networks). Wireless local area networks, operable in manners analogous to wired LANs, have also been developed and are utilized to communicate packets of data over a radio link. A HIgh PErformance Radio Local Area Network type 2 (HIPERLAN/2) standard promulgated by the ETSI BRAN (broadband radio access network) project sets forth a standard of operation of an exemplary wireless LAN. Mobile terminals operable therein transmit packet data upon a radio link to an access point of the infrastructure of the wireless LAN.

A frame structure is defined in the HIPERLAN-2 standard at a MAC (medium access control) layer defined therein. The MAC-frame includes four portions, a broadcast phase (BC), a downlink (DL) phase, an uplink (UL) phase, and a random access (RA) phase. Data communicated during the broadcast phase of the frame generally pertains to control information. The downlink and uplink phases carry user data and control data to, and from, a mobile terminal according to a reservation-based scheme. And, the random access phase permits random access by mobile terminals to random access channels defined therein. In contrast to the downlink and uplink phases, a reservation-based scheme is not utilized in the random access phase of the MAC-frame. The length of the MAC-frame is fixed to be of a 2 ms duration, but the length of each phase of the frame is selectable.

While communication of data upon a random access channel of the random access phase provides a simple manner by which to effectuate communication of data, lack of coordination between separate sending stations of separate sending-receiving station pairs might result in collisions of data if communicated concurrently upon the same random access channel. That is to say, separate sending stations might attempt to transmit separate packets of data during overlapping time periods. Typically, when a collision condition occurs, the packets of data interferes with one another to an extent to prevent the recreation of their informational content subsequent to reception at their respective receiving stations.

To reduce the likelihood of occurrence of collisions between packets of data transmitted upon the random access channels beneath a threshold, an adequate number of random access channels is required to be allocated to form a portion of the MAC-frame. By increasing the number of random access channels of which a MAC-frame is formed, the likelihood of a collision occurring upon any particular random access channel is reduced. However, by increasing the number of random access channels, the efficiency of channel utilization is reduced, particularly because the MAC-frame is of a fixed length.

Existing manners, and proposed manners, by which to select the number of random access channels to form a portion of a MAC-frame generally do not provide a quantitative manner by which to select the number of random access channels of which to form the random access portion of a MAC-frame. That is to say, presently, there generally is no manner by which to quantitatively balance the competing goals of minimizing the likelihood of the occurrence of a collision and the goal of maximizing communication capacity in the communication system.

A manner by which to allocate the number of random access channels to form a portion of a frame on a quantitative basis would therefore be advantageous.

It is in light of this background material related to communications in a frame-formatted communication system that the significant improvements of the present invention have evolved.

SUMMARY OF THE INVENTION

The present invention, accordingly, advantageously provides apparatus, and an associated method, by which to allocate random access channels in a frame-formatted communication system.

Quantitative determinations are made of anticipated communications upon random access channels during the frame. Determinations are made dynamically, such as on a frame-by-frame basis. When a determination is made of an increased need to communicate upon random access channels, increased numbers of random access channels are allocated to form a portion of the frame. And, conversely, if a determination is made that lessened numbers of random access channels are anticipated to be needed to effectuate communications, the frame is formed of lessened numbers of random access channels.

In one implementation, an embodiment of the present invention is operable to form a portion of wireless LAN (local area network), such as that set forth in the HIPERLAN/2 (high performance local area network/type 2) standard. In such a wireless LAN, a plurality of mobile terminals are operable to communicate by way of a wireless link with an access point when positioned within a coverage area defined by the access point. A typical wireless LAN also includes a plurality of access points, each defining a coverage area and between which communication handovers are effectuable as a mobile terminal travels between coverage areas defined by successive ones of the access points.

Frame-formatted communications are defined in the HIPERLAN/2, as well as other, standards. In particular, the HIPERLAN/2 standard defines a MAC (medium access control)-frame structure containing a variable number of random access channels. The random access channels provide random access to mobile terminals to send messages to the network infrastructure of the LAN to request the allocation of dedicated communication channels to effectuate communications thereon. Operation of an embodiment of the present invention determines how many random access channels are required to be needed during a frame to ensure that the likelihood of the occurrence of the collision upon a random access channel is less than a selected threshold.

In one aspect of the present invention, determinations are made as to the number of mobile terminals which are associated with an access point. These determinations are made, for instance, responsive to registration messages sent at selected intervals by mobile terminals. Registration messages are sent by the mobile terminals also during their initial powering-on. And, determination of the number of mobile terminals associated with an access point is also responsive to detection of indications of handovers of communications from another access point. Responsive to such determinations of the mobile terminals associated with an access point, selection is made of the number of random access channels to form a portion of a frame.

In another aspect of the present invention, determinations are made both of the number of mobile terminals associated with an access point but also of the number of such associated mobile terminals to which channel allocations have been reserved. A difference is formed between the number of mobile terminals associated with the access point and the number of mobile terminals which further already have a channel assignment allocated thereto. Selection of the number of random access channels to allocate to form a portion of the frame is made responsive to such difference. At least one random access channel is assigned to each frame even if all of the mobile terminals associated with the access point also have allocated thereto a channel allocation. Thereby, if a mobile terminal, previously unassociated with the access point, becomes associated with the access point during the time period of the frame, a random access channel is available thereto upon which to transmit a message thereon by the additional mobile terminal.

In another aspect of the present invention, determination is also made as to the communication-service type anticipated to be communicated during the frame. The communication-service type has associated therewith a priority level. Certain communication-service types are more time-sensitive than others. If the anticipated levels of communication of a communication-service type of a high priority level is small, the number of random access channels determined to be necessary is selected to be correspondingly large. If, conversely, the amount of communications of the communication-service type of a high priority level is relatively large, the number of random access channels should be fairly small. Selection of the number of random access channels of which to form a portion of the frame is made responsive thereto.

In another aspect of the present invention, the access point is further capable of selectably generating a wake-up indicator during the frame. A determination is made as to whether the access point is to generate a wake-up indicator during the frame. Selection of the number of random access channels of which to form a portion of the frame is made responsive to such determinations. If determination is made that the access point is to send a wake-up indicator during the frame, selection is made to increase the number of random access channels of which to form a portion of the frame.

Because quantitative determinations are made of anticipated communication conditions during the frame, allocation of the number of random access channels most appropriate to form a portion of the frame is better made. As a result, a better balance is able to be made between increasing the number of random access channels to minimize the likelihood of collision conditions thereupon, and most efficiently utilizing the communication capacity of the allocated spectrum to the communication system.

In these and other aspects, therefore, apparatus, and an associated method, is provided for selecting a selected number of random access channels of which to form a portion of a frame. The frame is defined in a multi-user communication system in which at least one sending station is capable of random access to a selected number of random access channels to Ocommunicate data to a receiving station. The selected number of random access channels form a portion of a frame of communication channels. A determiner is coupled to receive indications of a parameter indicative of anticipated communications between the at least one sending station and the receiving station. The determiner determines a number of random access channels needed to maintain a collision possibility of collisions between data communicated by the at least one sending station upon a random access channel of the frame beneath a threshold. A selector is operable responsive to determination made by the determiner. The selector selects how many random access channels are to form the portion of the frame.

A more complete appreciation of the present invention and the scope thereof can be obtained from the accompa-

nying drawings, which are briefly summarized below, the following detailed description of the presently-preferred embodiments of the invention, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a functional block diagram of the communication system in which an embodiment of the present invention is operable.

FIG. 2 illustrates the frame format of a MAC (medium access control) frame pursuant to which communications are formatted during operation of an exemplary implementation of the communication system shown in FIG. 1.

FIG. 3 illustrates a message sequence diagram showing the message sequencing generated during operation of an embodiment of the present invention.

FIG. 4 illustrates a method flow diagram listing the method of operation of an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, a communication system, shown generally at **10**, provides for the communication of packet data between a mobile terminal **12** and an access point **14** by way of a radio link **16**. The communication system **10** is a multi-user communication system permitting a plurality of mobile terminals **12** to communicate packet data with the access point **14**, such as pursuant to a plurality of different communication sessions. While only a single mobile terminal **12** is shown in the figure, in an actual communication system, a plurality of such mobile terminals are operable to communicate packet data with the access point.

In the exemplary implementation, the communication system **10** is constructed to correspond to the specifications set forth in the HIPERLAN/2 (high performance local area network/type 2) standard, promulgated by the ETSI. In such a communication system, frame-formatted data is communicated during selected time slots within a MAC (medium access control)-frame which includes one or more random access channels (RACH). The number of random access channels included to form a portion of the frame is selectable.

During operation of an embodiment of the present invention, the number of random access channels of which the frame is formed is selected in a manner to balance the competing needs of maximizing communication capacity while also minimizing collision conditions upon a random access channel. In other implementations, an embodiment of the present invention is also operable to permit the selection of the number of random access, or other, channels of which to form a portion of the frame. The mobile terminal **12** is, accordingly, also representative of a sending station, and the access point **14** is representative of a receiving station, which are connected theretogether by way of a random access channel and upon which the sending station sends a message to the receiving station.

When, and as described herein, the communication system comprises a wireless LAN as defined in the HIPERLAN/2 standard, separate access points **14** are installed at separate locations of the geographic area in which the LAN is installed. For instance, separate access points are positioned at different floors of a building structure or in separate locations of a single floor of the building structure. Each access point includes transceiver circuitry **18** capable of two-way communication of packets of data. That is to say, the MAC-frame defined in the communication system includes both an uplink and a downlink phase permitting transmission by the mobile terminal **12** of packets of data upon an uplink channel to the transceiver circuitry and to permit packets of data generated at the transceiver circuitry **18** to be transmitted upon a downlink channel to the mobile terminal. The MAC-frame also includes a broadcast phase upon which data is broadcast by the transceiver circuitry of the access point to mobile terminals positioned within a coverage area, here shown at **22**, defined by the access point.

The access point **14** is here further shown to include a controller **24**, here including functional elements. Namely, the controller is shown to include a random access channel allocator **26**, a radio link controller **28**, and a DLC (data link control) scheduler **32**. The random access channel allocator is coupled to the radio link controller by way of the line **34**, and the random access channel allocator is coupled to the DLC scheduler by way of the line **36**. And, the controller and scheduler are connected together by way of the line **38**. The functional elements of the controller **34** are operable to allocate, within a frame, the number of random access channels which form a portion of the frame. Each of the functional elements of the controller are coupled to the transceiver circuitry of the access point.

During operation of the communication system, a user of the mobile terminal **12** might want to initiate communications therethrough. That is to say, a user of the mobile terminal might initiate a call. One of the first steps in the initiation of the call is a generation of a request by the mobile terminal for the allocation by the system of resources to the mobile terminal to effectuate a selected communication service. The resource request is generated upon a random access channel for communication to the access point **14** and subsequent action thereon. The request for resources generated upon a random access channel is susceptible to collision with other messages generated upon the same channel, to which there is random access.

When, and if, the request for resources is received at the access point, an appropriate allocation of channel resources are provided to effectuate the requested communication service.

As many mobile terminals might be positioned within the coverage area **22** of the access point, any of the mobile terminals is capable of generating a request for resources upon a random access channel to which random access is permitted. Operation of the functional elements of the controller **24** selects the number of random access channels allocated to a frame to ensure better that the likelihood of the occurrence of a collision condition upon a random access channel is beneath a threshold.

The random access channel allocator **26** is further shown, therefore, to include a determiner **42** and a selector **44** coupled thereto. The determiner is coupled, by way of the line **34**, to the radio link controller **28** and, by way of the line **36**, to the DLC scheduler **32**. It should be noted that the determiner, selector **44**, and also the allocator **26** are functional entities. Such entities can also form portions of the radio link controller **28** and the DLC scheduler **32**.

The radio link controller **28** is here operable to perform the functions of radio link control set forth in the HIPERLAN/2 standard. The radio link controller is responsible for mobile terminal-access point association and disassociation, connection setup, and other aspects of control of the radio link **16**. The radio link controller further is aware of which mobile terminal **12**, and how many mobile

terminals 12, are associated with the access point 14. And, such information is provided, by way of the line 34, to the determiner 42 of the random access channel allocator 26.

A mobile terminal becomes associated with the access point through the generation of a registration message, as noted above, or pursuant to a handover of communications from another access point to the access point 14. When a registration message is generated by a mobile terminal 12, the transceiver circuitry 18 detects such message and provides indications of the message, by way of the line 20, to the radio link controller. The line 46 represents signals generated by network infrastructure of the communication system during a handover of communications, and through such signals, the radio link controller is notified of the new association of a mobile terminal involved in the handover of communications, to the radio link controller. Indications of the number of mobile terminals associated with the access point 14 and provided to the random access channel allocator by way of the line 34 is made, in one implementation, responsive to a request for such information by the random access channel allocator.

The DLC scheduler 32, in the exemplary implementation, is also operable to perform the functions set forth in the HIPERLAN/2 standard. The DLC scheduler is operable, amongst other things, to distribute available bandwidth, i.e., channel resources, to individual mobile terminals responsive to resource requests generated by such mobile terminals. When a resource request is detected by the transceiver circuitry 18 of the access point, indications of such detection are provided to the DLC scheduler by way of the line 20.

In one embodiment of the present invention, the number of random access channels which are allocated to form a portion of a frame is proportional to the number of mobile terminals associated with the access point, here referred to as the number of "associated mobile terminals." The determiner determines the number of mobile terminals associated with the access point 14 responsive to indications of such number provided thereto by the radio link controller, and the selector 44 is operable to calculate the number of random access channels of which to include as a portion as a frame according to the following equation:

$$\#\,RCH=\alpha^{*}\,(\#\text{ associated } MTs)$$

wherein:

α is a parameter of a value less than 1; and

"# associated MTs" is the number of associated mobile terminals, associated with the access point.

In another implementation, the DLC scheduler is operable to provide indications to the determiner of the number of mobile terminals to which resources have been allocated for the effectuation of communication services. Once resources are allocated for such communication, the mobile terminal would likely not utilize a random access channel. And, the selector 44 is operable to select the number of random access channels, # RCH, of which to allocate to form a portion of a frame according to the following equation:

$$\#\,RCH=\max\,[\beta^{*}(\#\text{ associated } MTs-\#MTs\text{ with uplink capacity}),\,1]$$

wherein:

β is a parameter of value less than 1;

"# associated MTs" is the number of mobile terminals associated with the access point; and

"# MTs with uplink capacity" is the number of mobile terminals to which channel resources have already been allocated.

Analysis of this equation indicates that, if the number of mobile terminals to which channel resources are assigned in the frame is small compared with the number of associated mobile terminals, the number of random access channels allocated to the frame is relatively large. Conversely, if all, or a substantial portion, of the associated mobile terminals already have channel resources associated thereto, the number of random access channels allocated to the frame is relatively small, as low as one random access channel. A minimum number of random access channels, here one, permit newly-arrived mobile terminals within the coverage area 22 to become associated with the access point. The number of random access channels calculated as above-noted is rounded-off to form an integer value.

In a further embodiment, the determiner 42 is further provided with indications of the communication-service type of communication services to be effectuated during the frame. And, the selector 44 is operable, responsive to determination of the determiner, of the communication-service types of communication services to be effectuated, to select a number of random access channels of which to form a portion of the frame. If only a small amount of the communications to be effectuated during the frame are of a communication-service type to which a high priority level is associated, the number of random access channels selected by the selector to form a portion of the frame is fairly large, even though the transmission capacity of such random access channels could be used to communicate data with a low priority. Such selection is made for the reason that transmission delays of the requests for resources of newly-associated mobile terminals is of significance. Thus, mobile terminals which do not have uplink channel capacity resources already allocated thereto, but communication-services to which high priority is associated have a high probability of success when requesting, with a resource request, channel resources utilizing a random access channel.

In another embodiment, the access point 14 is operable to send, during selected frames, wake-up indicators at a first a portion of the frame to indicate whether the frame contains a wake-up message. A mobile terminal in a sleep mode must wake-up to listen to the contents of the frame if the first portion of the frame includes a wake-up indicator. If the frame does not contain a wake-up message for a particular mobile terminal, the mobile terminal is permitted to continue to remain in a sleeping mode. However, as the wake-up indicator is frequently utilized, it is useful for the mobile terminal in the sleeping mode to remain synchronized to the channel and the MAC-frame defined thereon. In such a situation, the selector reserves a large number of random access channels to form a portion of the MAC-frame which contains a wake-up indicator. Thereby, a mobile terminal is able to estimate the best opportunity for transmission in a random access channel, thereby reducing the possibility of collision conditions. In other words, a MAC-frame that includes a wake-up indicator must awaken the mobile terminal. Once awakened, the mobile terminal also checks internal buffers to see if a message is to be communicated by the mobile terminal. Therefore, during MAC-frames which include wake-up indicators, there is an increased likelihood that an increased number of mobile terminals shall check their respective buffers and determine that messages are to be transmitted therefrom.

FIG. 2 illustrates a MAC-frame, shown generally at 58, as defined in the HIPERLAN/2 standard. The frame includes a broadcast (BC) phase portion 62, a downlink (DL) phase portion 64, an uplink (UL) phase portion 66, and a random access channel (RCH) portion 68. Operation of an embodiment of the present invention selects the number of random

access channels of which to form the random access channel portion phase 68. Because quantitative determinations are made as to the likelihood of the need to utilize a random access channel, selection of the number of random access channels of which to form the MAC-frame is made upon a quantitative basis. Also, selection is dynamically made, on a frame-by-frame basis.

FIG. 3 illustrates a message sequence diagram, shown generally at 72, which shows the sequencing of messages generated during operation of the communication system shown in FIG. 1. First, as indicated by the segment 74, messages are sent to an access point. The messages represented by the segment 74 are representative of registration messages sent by a mobile terminal to an access point. The segment 74 alternately could represent messages sent to the access point from elsewhere, such as from other locations of the network infrastructure to which the access point is coupled indicating handovers of communications to the access point. And, the message could also be representative of indications of communication-service types of communication services to be effectuated during a frame. Indications of such messages are provided to the random access channel allocator 26. The allocator 26 is operable to select the number of random access channels which are to form a portion of the frame. Indication of the channel formation are broadcast, here indicated by the segment 82, to the mobile terminals. Thereafter, and as indicated by the segment 84, random access messages are communicated upon the allocated random access channels.

FIG. 4 illustrates a method, shown generally at 88, of an embodiment of the present invention. The method is operable to select a selected number of random access channels which form a portion of a frame defined in a frame-formatted communication system.

First, and as indicated by the block 92, the number of random access channels needed to maintain a collision possibility of collisions between data communicated by the at least one sending station upon a random access channel of the frame beneath a threshold is determined. Then, and as indicated by the block 92, selection is made of how many random access channels are to form the portion of the frame. Thereby, a quantitative manner is provided by which to allocate random access channels to form a portion of a frame.

These descriptions are of preferred examples for implementing the invention, and the scope of the invention should not necessarily be limited by this description. The scope of the present invention is defined by the following claims.

We claim:

1. In a multi-user, frame-formatted communication system in which fixed-length frames are defined, each frame having a random-access portion and a nonrandom access portion, the communication system having at least one mobile terminal that is capable of random access to a selected number of random access channels, defined within the random-access portion of each frame, to communicate data to an access point, an improvement of apparatus for selecting the selected number of the random access channels defined within the random-access portion, thereby to define, in part, how much of the frame is formed of the random-access portion, said apparatus comprising:

a determiner coupled to receive indications of a parameters indicative of anticipated communications between each of the at least one mobile terminal and the access point during the frame, said determiner for determining a number of random access channels needed to maintain a collision possibility of collisions between data communicated by the at least one mobile terminal upon a random access channel of the frame beneath a threshold; and

a selector in the access point operable responsive to determination made by said determiner, said selector for selecting how many random access channels are defined within the random-access portion of the frame, selection made by said selector being determinative of how much of the frame is comprised of the random access portion and determinative, at least in part, of how much of the frame is comprised of the nonrandom access portion.

2. The apparatus of claim 1 wherein the indications of the parameter indicative of anticipated communication between each of the at least one mobile terminal and the access point which said determiner is coupled to receive comprise indications of how many of the at least one mobile terminal are associated with the access point.

3. The apparatus of claim 2 wherein the access point defines a coverage area and wherein each of the at least one mobile terminal is associated with the access point when the mobile terminal is positioned within the coverage area of the access point.

4. The apparatus of claim 3 wherein each of the at least one mobile terminal is operable to send a registration message, detection of the registration message at the access point indicating to the access point association of the mobile terminal from which the registration message is sent to the access point.

5. The apparatus of claim 4 wherein selections made by said selector of how many random access channels are to be defined within the random-access portion of the frame are proportional to how many mobile terminals are determined by said determiner to be associated with the access point.

6. The apparatus of claim 3 wherein the indications of the parameter indicative of the anticipated communications between the at least one mobile terminal and the access point further comprise indications of how many of the at least one mobile terminal associated with the access point are assigned to communicate during the nonrandom access portion of the frame.

7. The apparatus of claim 6 wherein selections made by said selector of how many random access channels are to be defined within the nonrandom access portion of the frame are proportional to a difference calculated of how many mobile terminals are determined to be associated with the access point less how many of the mobile terminals are assigned to communicate during the nonrandom access portion of the frame.

8. The apparatus of claim 7 wherein the selections made by selector select at least one random access channel to form a portion of the frame.

9. The apparatus of claim 1 wherein the indications of the parameter indicative of anticipated communications between the at least one mobile terminal and the access point that said determiner is coupled to receive comprise indications of a communication-service type of communications to be effectuated with each of the at least one mobile terminal.

10. The apparatus of claim 9 wherein said determiner further assigns a priority level to each communication-service type, of which indications thereof are reserved thereat.

11. The apparatus of claim 10 wherein selection made by said selector of how many random access channels are defined within the random-access portion of the frame is proportional to the priority level assigned to the communication-service type of the communications to be effectuated with the at least one mobile terminal.

12. The apparatus of claim 1 wherein the mobile terminal is operable in a sleep mode and in a nonsleep mode, wherein the access point is further selectably operable to send a wake-up indication during the frame and wherein the indications of the parameter indicative of anticipated communications between the at least one mobile terminal and the access point that said determiner is coupled to receive comprises an indication of whether the wake-up indication is to be sent during the frame.

13. The apparatus of claim 12 wherein selections made by said selector of how many random access channels are to form a portion of the frame is dependent, at least in part, upon whether a wake-up indication is to be sent during the frame.

14. The apparatus of claim 13 wherein a first number of random access channels is selected by said selector when the wake-up indication is to be sent during the frame and a second number of random access channels is selected by selector when a wake-up indication is not to be sent during the frame, the first number greater than the second number.

15. The apparatus of claim 1 wherein the multi-user communication system comprises a wireless LAN (local area network) wherein the access point comprises a portion of the network infrastructure of the wireless LAN, said determiner and said selector forming portions of the network infrastructure.

16. In a method for communicating in a multi-user, frame-formatted communication system in which fixed-length frames are defined, each frame having a random-access portion and a nonrandom access portion, the communication system having at least one mobile terminal that is capable of random access to a selective number of random access channels, defined within the random-access portion of each frame, to communicate data to an access point, an improvement of a method for selecting the selected number of the random access channels defined within the random-access portion, thereby to define how much of the frame is formed of the random-access portion of the frame, said method comprising:

determining a number of random access channels needed to maintain a collision possibility of collisions between data communicated by the at least one mobile terminal upon a random access channels of the frame beneath a threshold responsive to indications of parameters indicative of anticipated communications between each of the at least one mobile terminal and the access point; and

selecting by the access point, responsive to determinations made during said operation of determining, how many random access channels are defined within the random-access portion of the frame, selection being determinative of what portion of the frame is comprised of the random access channels and determinative, at least in part, of how much of the frame is comprised of the nonrandom access portions.

17. The method of claim 16, further comprising the initial operation of generating indications of a parameter indicative of anticipated communications between the at least one mobile terminal and the access point.

18. The method of claim 17 wherein the indications generated during said operation of generating comprise indications of how many of the at least one mobile terminal are associated with the access point.

19. The method of claim 18 wherein the indications generated during said operation of generating further comprise indications of how many of the at least one mobile terminal associated with the access point are assigned to communicate during the nonrandom access portion of the frame.

20. The method of claim 17 wherein the indications generated during said operation of generating comprise indications of a communication-service type of communications to be effectuated with the at least one mobile terminal.

21. The method of claim 17 wherein the access point is further selectably operable to send a wake-up indication during the frame and wherein the indications generated during said operation of generating comprise an indication of whether the wake-up indication is to be sent during the frame.

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(45) **Date of Patent: Aug. 12, 2003**

(54) **METHOD TO DYNAMICALLY ADJUST THE MAXIMUM BACK OFF TIME OF AN ETHERNET CONTROLLER IN A HALF DUPLEX NETWORK**

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(52) **U.S. Cl.** **370/448**
(58) **Field of Search** 370/445, 446, 370/447, 448, 229, 230; 709/235

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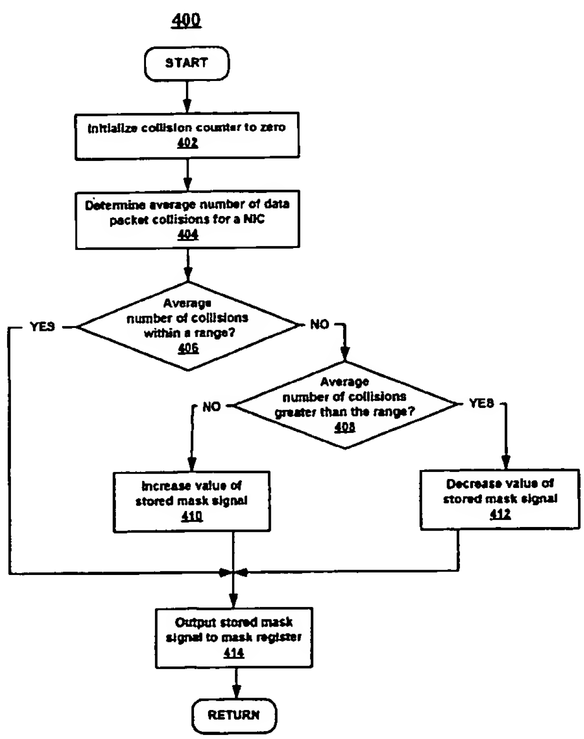
(57) **ABSTRACT**

A method to dynamically adjust the maximum back off time of an Ethernet controller in a half duplex network. Specifically, one embodiment of the present invention includes a method for providing priority to a peripheral component (e.g., half duplex Network Interface Card) in a congested network. The method includes the step of determining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over a network. Furthermore, the method includes the step of detecting a collision of a second data packet during transmission of the second data packet by the peripheral component coupled to the network. Additionally, the method also includes the step of determining a back off time. It should be appreciated that the back off time is substantially equal to or less than the maximum back off time limit. Moreover, the method includes the step of causing the peripheral component to wait the back off time before trying to retransmit the second data packet over the network.

21 Claims, 4 Drawing Sheets



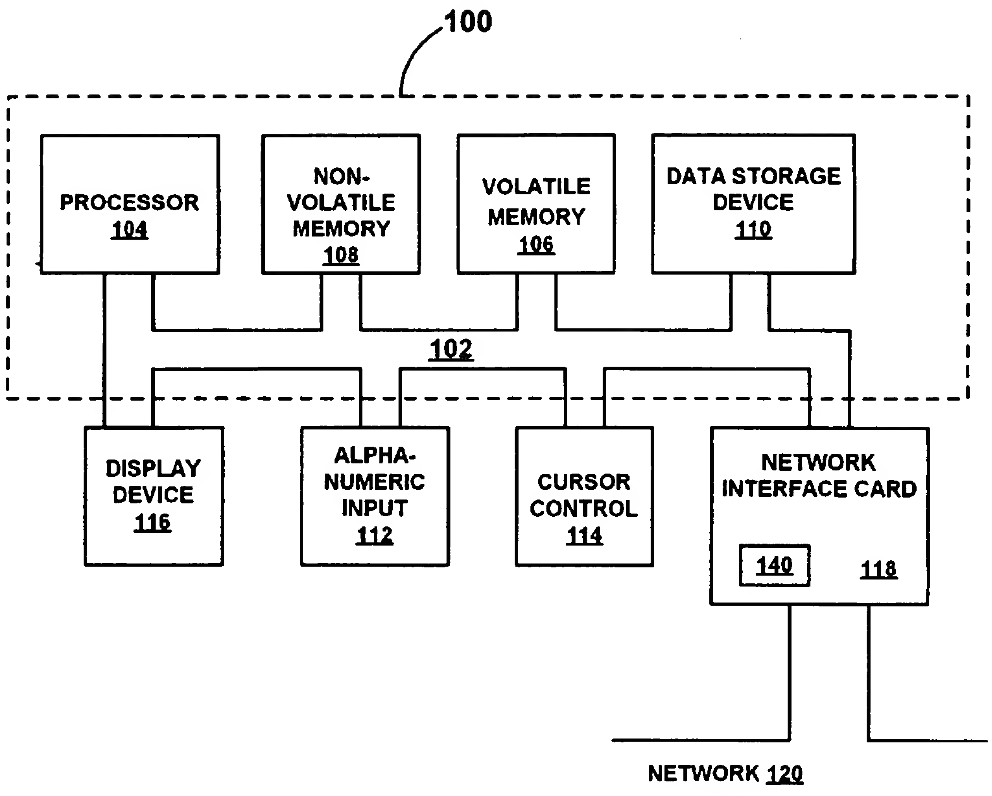

100
PROCESSOR
104
NON-
VOLATILE
MEMORY
108
VOLATILE
MEMORY
106
DATA STORAGE
DEVICE
110
102
DISPLAY
DEVICE
116
ALPHA-
NUMERIC
INPUT
112
CURSOR
CONTROL
114
NETWORK
INTERFACE CARD
140
118
NETWORK 120

FIG.1

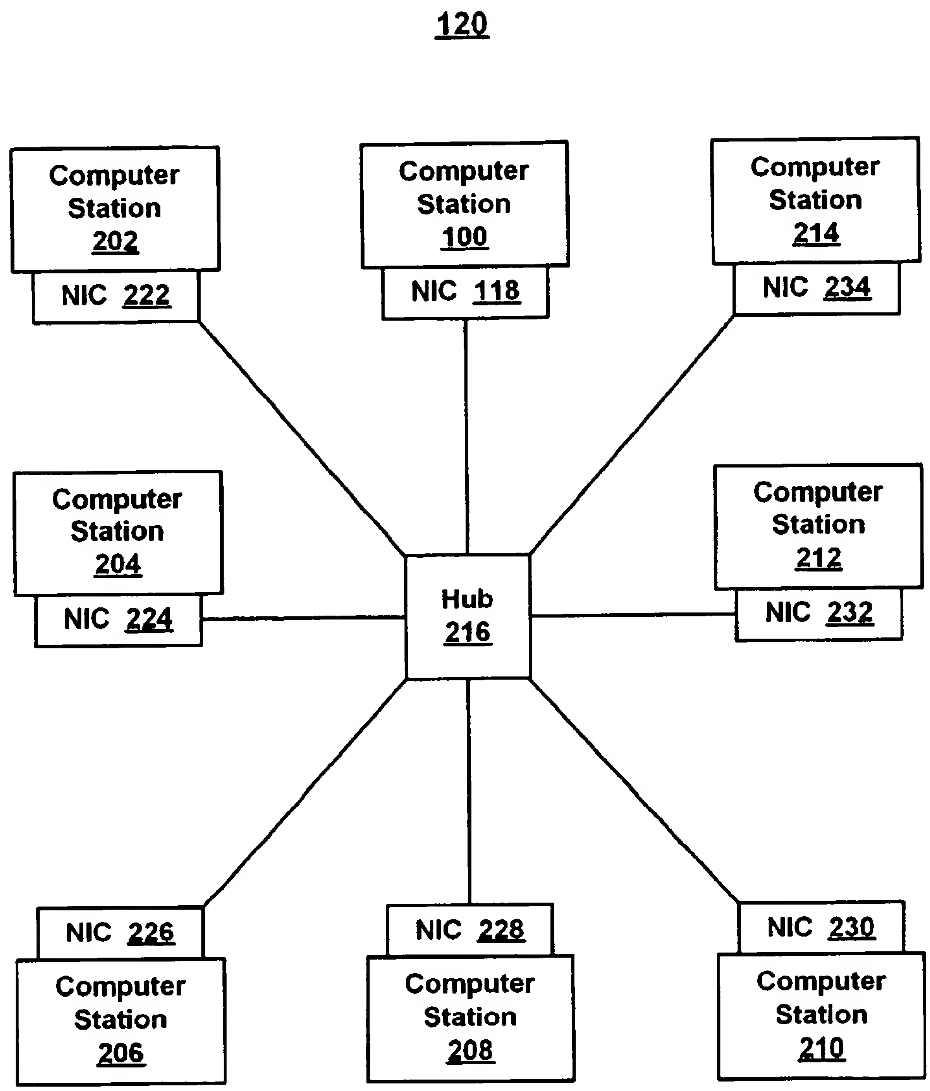

120
Computer Station 202
NIC 222
Computer Station 100
NIC 118
Computer Station 214
NIC 234
Computer Station 204
NIC 224
Hub 216
Computer Station 212
NIC 232
NIC 226
Computer Station 206
NIC 228
Computer Station 208
NIC 230
Computer Station 210

FIG. 2

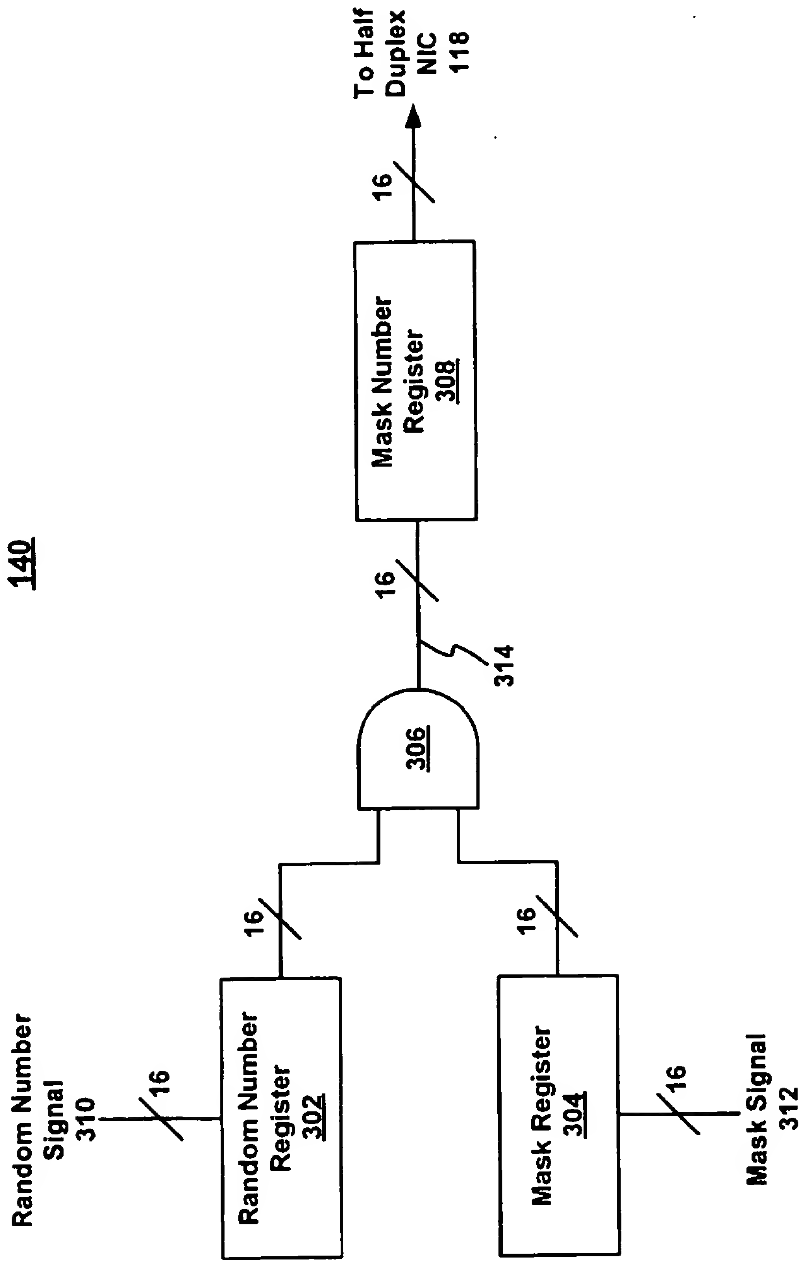

140
Random Number Signal 310
16
Random Number Register 302
16
Mask Register 304
16
Mask Signal 312
16
306
314
16
Mask Number Register 308
16
To Half Duplex NIC 118

FIG. 3

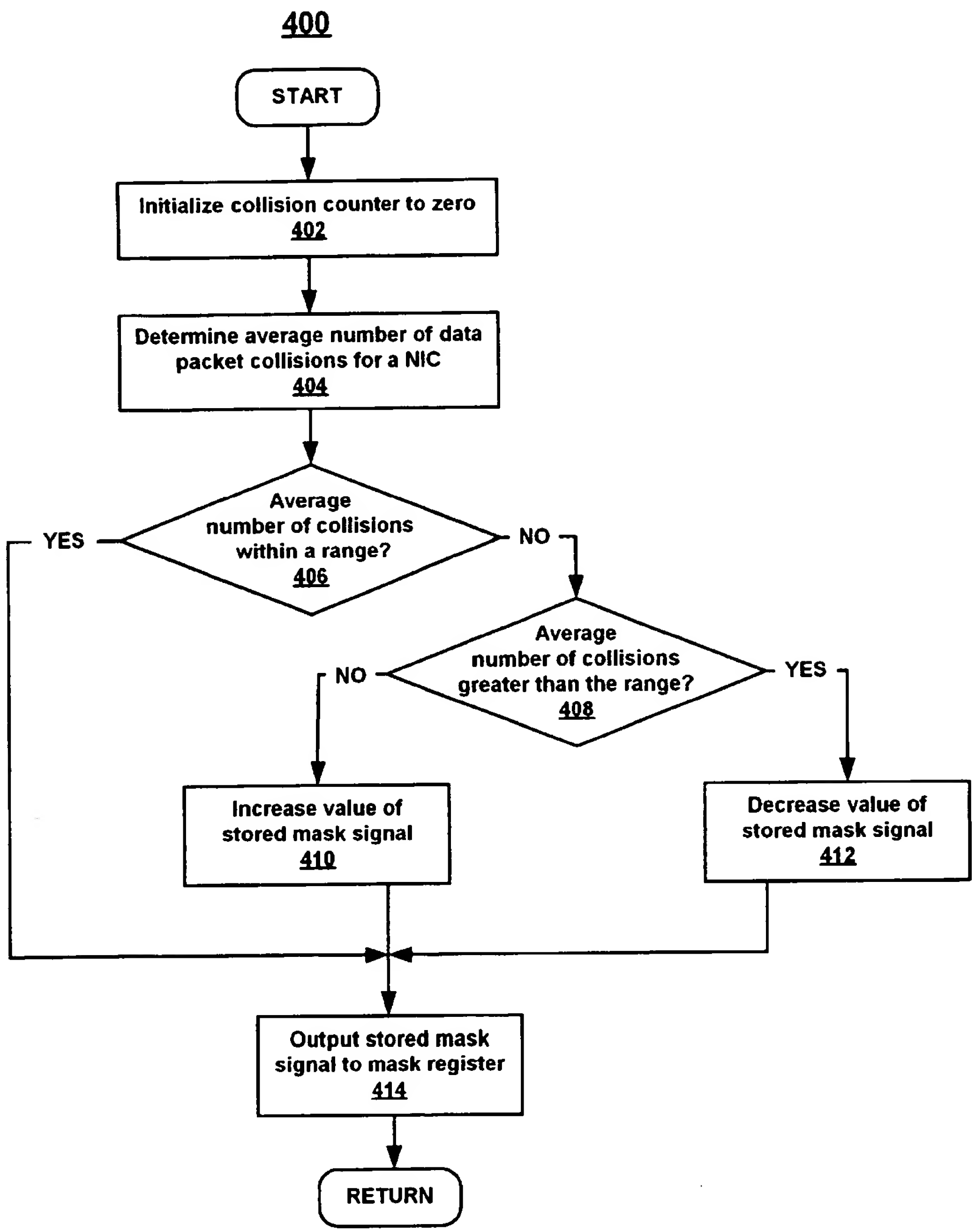

400
START
Initialize collision counter to zero
402
Determine average number of data packet collisions for a NIC
404
Average number of collisions within a range?
406
YES
NO
Average number of collisions greater than the range?
408
NO
YES
Increase value of stored mask signal
410
Decrease value of stored mask signal
412
Output stored mask signal to mask register
414
RETURN

FIG. 4

METHOD TO DYNAMICALLY ADJUST THE MAXIMUM BACK OFF TIME OF AN ETHERNET CONTROLLER IN A HALF DUPLEX NETWORK

TECHNICAL FIELD

The present invention relates generally to the field of computer networking. More particularly, the present invention relates to the field of data packet transmissions within an Ethernet network.

BACKGROUND ART

Computers have become an integral tool used in a wide variety of different applications, such as in finance and commercial transactions, computer-aided design and manufacturing, health care, telecommunication, education, etc. Computers are also finding new applications as a result of advances in hardware technology and rapid development in software technology. Furthermore, a computer system's functionality is dramatically enhanced by coupling stand-alone computers together to form a computer network. In a computer network, users may readily exchange files, share information stored on a common database, pool resources, and communicate via electronic mail (e-mail) and via video teleconferencing.

One popular type of computer network is known as a local area network (LAN). LANs connect multiple computers together such that the users of the computers can access the same information and share data. Typically, in order to be connected to a LAN, a general purpose computer requires an expansion board generally known as a Network Interface Card (NIC). Essentially, the NIC works with the operating system and Central Processing Unit (CPU) of a host computer to control the flow of information over the LAN. Some NICs may also be used to connect a computer to the Internet.

Typically, NICs are also used to communicate over a LAN communications network standard referred to as Ethernet. It is appreciated that if two NICs coupled to an Ethernet network each try to transmit a packet or frame of data at the same time within a half duplex network, a collision of those packets occurs. As such, each NIC involved in the collision backs off a random amount of time before trying to retransmit their respective data packet. Within the Ethernet network, each half duplex NIC is allowed 16 collisions to transmit a current data packet before discarding it in order to begin transmitting a subsequent data packet. Furthermore, as the number of collisions of a particular data packet increases within the Ethernet network, the half duplex NIC has an increased possibility of backing off for a longer amount time.

It should be appreciated that more and more half duplex NICs can be coupled to the Ethernet network enabling more and more computers to access the same information and share data. But there are disadvantages associated with numerous half duplex NICs being coupled to the Ethernet network. One of the main disadvantages is that as more and more half duplex NICs are coupled to the Ethernet network, there is an increased possibility of more and more data packet collisions thereby resulting in a more congested network. As such, a half duplex NIC of a particular computer (e.g., file server) which handles a high volume of data packet traffic is unable to efficiently transmit its data packets because of an increased occurrence of data packet collisions.

Accordingly, a need exists for a method and system for providing transmission priority to a half duplex Network Interface Card (NIC) of a particular computer station (e.g., file server) which is coupled to a congested Ethernet network.

DISCLOSURE OF THE INVENTION

Embodiments of the present invention provide a method and system for providing transmission priority to a half duplex Network Interface Card (NIC) of a particular computer station (e.g., file server) which is coupled to a congested Ethernet network. Furthermore, embodiments of the present invention provide a method and system which achieves the above accomplishment and also provides a method and system to dynamically adjust the maximum back off time of a half duplex NIC coupled to an Ethernet network.

Specifically, one embodiment of the present invention includes a method for providing priority to a peripheral component (e.g., half duplex Network Interface Card) in a congested network. The method includes the step of determining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over a network. Furthermore, the method includes the step of detecting a collision of a second data packet during transmission of the second data packet by the peripheral component coupled to the network. Additionally, the method also includes the step of determining a back off time. It should be appreciated that the back off time is substantially equal to or less than the maximum back off time limit. Moreover, the method includes the step of causing the peripheral component to wait the back off time before trying to retransmit the second data packet over the network.

In another embodiment, the present invention includes a computer system. The computer system includes a processor, an addressable data bus coupled to the processor, and a computer usable memory coupled to communicate with the processor for performing a method for providing priority to a peripheral component (e.g., half duplex Network Interface Card) coupled to a network. Specifically, the method includes the step of determining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over the network. Furthermore, the method includes the step of detecting a collision of a second data packet during transmission of the second data packet by the peripheral component coupled to the network. Additionally, the method includes the step of ascertaining a back off time. It should be appreciated that the back off time is substantially equal to or less than the maximum back off time limit.

In still another embodiment, the present invention includes a computer readable medium having computer readable code embodied therein for enabling a peripheral component coupled to a network to gain priority. Specifically, the computer readable medium causes the peripheral component to perform the step of ascertaining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over the network. Furthermore, the computer readable medium causes the peripheral component to perform the step of detecting a collision of a second data packet during transmission of the second data packet by the peripheral component coupled to the network. Moreover, the computer readable medium causes the peripheral component to perform the step of ascertaining a back off time. It should be appreciated that the back off time is substantially equal to or less than the maximum back off time limit. Additionally, the

computer readable medium causes the peripheral component to perform the step of causing the peripheral component to wait the back off time before trying to retransmit the second data packet over the network.

These and other advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiments which are illustrated in the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

FIG. 1 is a block diagram of an exemplary computer system used in accordance with one embodiment of the present invention.

FIG. 2 is a block diagram of an Ethernet network used in accordance with one embodiment of the present invention.

FIG. 3 is a schematic diagram of a back off time restrictor circuit in accordance with one embodiment of the present invention which is implemented as part of a half duplex Network Interface Card (NIC).

FIG. 4 is a flowchart of steps performed in accordance with one embodiment of the present invention for dynamically adjusting the value of the mask signal of FIG. 3.

The drawings referred to in this description should not be understood as being drawn to scale except if specifically noted.

BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

Some portions of the detailed descriptions which follow are presented in terms of procedures, logic blocks, processing, and other symbolic representations of operations on data bits within a computer memory. These descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. In the present application, a procedure, logic block, process, etc., is conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. It has proved convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussions, it is appreciated that throughout the present invention, discussions utilizing terms such as "detecting", "determining", "causing", "generating", "receiving", "using", "transmitting" or the like, refer to the actions and processes of a computer system, or similar electronic computing device. The computer system or similar electronic computing device manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices. The present invention is also well suited to the use of other computer systems such as, for example, optical and mechanical computers.

Computer System Environment of the Present Invention

With reference now to FIG. 1, portions of the present method and system are comprised of computer-readable and computer-executable instructions which reside, for example, in computer-usable media of a computer system. FIG. 1 illustrates an exemplary computer system **100** used to perform the present invention. It is appreciated that system **100** of FIG. 1 is only exemplary and that the present invention can operate within a number of different computer systems including general purpose networked computer systems, embedded computer systems, stand alone computer systems, and the like.

System **100** of FIG. 1 includes an address/data bus **102** for communicating information, and a central processor unit **104** coupled to bus **102** for processing information and instructions. Central processor unit **104** may be an 80×86-family microprocessor or any other type of processor. System **100** also includes data storage features such as a computer usable volatile memory **106** (e.g., random access memory, static RAM, dynamic RAM, etc.) coupled to bus **102** for storing information and instructions for central processor unit **104**, computer usable non-volatile memory unit **108** (e.g., read only memory, programmable ROM, flash memory, EPROM, EEPROM, etc.) coupled to bus **102** for storing static information and instructions for the central processor unit **104**, and a data storage unit **110** (e.g., a magnetic or optical disk and disk drive) coupled to bus **102** for storing information and instructions. System **100** of the present invention also includes an optional alphanumeric input device **112**, which includes alphanumeric and function keys, is coupled to bus **102** for communicating information and command selections to central processor unit **104**. System **100** also optionally includes a cursor control device **114** coupled to bus **102** for communicating user input information and command selections to central processor unit **104**. System **100** of the present embodiment also includes an optional display device **116** coupled to bus **102** for displaying information.

Referring still to FIG. 1, optional display device **116** may be a liquid crystal device, cathode ray tube, or other display

device suitable for creating graphic images and alphanumeric characters recognizable to a user. Optional cursor control device 114 allows the computer user to dynamically signal the two dimensional movement of a visible symbol (e.g., cursor) on a display screen of display device 116. Many implementations of cursor control device 114 are known in the art including a mouse, trackball, touch pad, joystick or special keys on alphanumeric input device 112 capable of signaling movement of a given direction or manner of displacement. Alternatively, it is appreciated that a cursor can be directed and/or activated via input from alphanumeric input device 112 using special keys and key sequence commands. The present invention is also well suited to directing a cursor by other means such as, for example, voice commands. A more detailed discussion of the method and system embodiments of the present invention are found below.

With reference still to FIG. 1, a half duplex Network Interface Card (NIC) 118 in accordance with one embodiment of the present invention coupled to bus 102 is connected to a network 120 and controls the flow of information of computer system 100 over network 120. Specifically, data packets, such as Ethernet packets, that are incoming and outgoing via network 120 are transmitted and received by half duplex NIC 118. Furthermore, a back off time restrictor circuit 140 in accordance with one embodiment of the present invention is implemented as part of half duplex NIC 118. A more detailed discussion of half duplex NIC 118 and back off time restrictor circuit 140 in furtherance of the present invention is found below. It should be appreciated that the present invention is well suited for other types of Network Interface Cards and is not strictly limited to a half duplex Network Interface Card.

Detailed Description of the Structure and Operation of the Present Invention

In the following description of embodiments of the present invention, a Network Interface Card is a peripheral component. Although the present embodiments specifically recite a Network Interface Card, the present invention is also well suited to an embodiment employing various other peripheral components. That is, the present invention is well suited to an embodiment in which the peripheral component is, for example, a PCMCIA (personal computer memory card international association) card. Similarly, the present invention is well suited to an embodiment in which the peripheral component is, for example, a compact form factor I/O (input/output) card. Additionally, the present invention is well suited to be used in an embodiment in which the peripheral component is, for example, a rate controller, a small computer system interface (SCSI) controller, a graphics card, and the like. Furthermore, the present invention is well suited to be used, for example, in a non-peripheral component environment such as an Application Specific Integrated Circuit (ASIC) disposed on a motherboard, an embedded circuit, and the like.

As previously mentioned above, embodiments of the present invention provide a method and system for providing transmission priority to a half duplex Network Interface Card (NIC) of a particular computer station (e.g., file server) which is coupled to a congested Ethernet network. Within one embodiment in accordance with the present invention, this is accomplished by dynamically adjusting the maximum back off time limit of the half duplex NIC in order to shorten the length of time of all or a portion of its back off times corresponding to data packet collisions. As such, the half duplex NIC potentially waits for a shorter amount of time before attempting to retransmit a particular data packet as compared to other typical half duplex NICs coupled to the Ethernet network. In this manner, the half duplex NIC in accordance with the present invention has transmission priority within the congested Ethernet network. It should be appreciated that one of the purposes for dynamically adjusting the maximum back off time limit of the half duplex NIC is to provide it transmission priority during fluctuations in the transmission congestion of the Ethernet network. Furthermore, another purpose for dynamically adjusting the maximum back off time limit is to prevent the half duplex NIC from over utilizing the transmission bandwidth of the Ethernet network. In other words, to restrain the half duplex NIC from completely hogging the transmission bandwidth of the Ethernet network.

With reference now to FIG. 2, which is a block diagram of an Ethernet network 120 used in accordance with one embodiment of the present invention. It should be appreciated that the present invention is not strictly limited to operation within Ethernet network 120. On the contrary, the present invention is well suited for operation within different types of communication networks. As such, Ethernet network 120 is an exemplary network used in accordance with one embodiment of the present invention. Within FIG. 2, it is appreciated that computer station 100 of FIG. 1 is coupled to and is part of Ethernet network 120. Specifically, half duplex NIC 118 of computer station 100 is coupled to a hub 216 of Ethernet network 120. The operation and functionality of hub 216 is well known by those of ordinary skill in the art. Moreover, half duplex NICs 222, 224, 226, 228, 230, 232 and 234 of computer stations 202, 204, 206, 208, 210, 212 and 214, respectively, are each coupled to hub 216. By coupling half duplex NICs 222–234 and 118 in this manner, users of computer stations 202–214 and 100 have access to the same information and are able to share data within Ethernet network 120.

Within Ethernet network 120, it is appreciated that if two or more of half duplex NICs 222–234 and 118 try to transmit a data packet or frame at the same time, a collision of those data packets occurs. As such, each half duplex NIC involved in the collision backs off a random amount of time before trying to retransmit their respective data packet. Each one of half duplex NICs 222–234 and 118 is allowed 16 collisions to transmit a particular data packet before discarding it in order to begin transmitting a subsequent data packet. Additionally, as the number of collisions of a particular data packet increases up to the value of 10, half duplex NICs 222–234 have an increased possibility of backing off for a longer amount time. As to this particular functionality, it is important to note that half duplex NIC 118 of computer station 100 does not operate in the same manner as half duplex NICs 222–234 of computer stations 202–214.

Specifically, one embodiment in accordance with the present invention dynamically adjusts the maximum back off time limit of half duplex NIC 118 of FIG. 2 in order to shorten the length of time of all or a portion of its back off times corresponding to data packet collisions. As such, the back off times of half duplex NIC 118 are substantially equal to or less than the maximum back off time limit. In this manner, half duplex NIC 118 potentially waits for a shorter amount of time before attempting to retransmit a particular data packet as compared to half duplex NICs 222–234 of Ethernet network 120. As such, half duplex NIC 118 achieves transmission priority over half duplex NICs 222–234 of computer stations 202–214 within Ethernet network 120.

Referring now to FIG. 3, which is a schematic diagram of a back off time restrictor circuit 140 implemented as part of

half duplex NIC 118, in accordance with one embodiment of the present invention. It should be appreciated that the present invention is well suited for a variety of different embodiments for performing the functionality of back off time restrictor circuit 140. As such, back off time restrictor circuit 140 is an exemplary circuit used in accordance with one embodiment of the present invention. One of the main functions of back off time restrictor circuit 140 is to dynamically restrict the length of time of all or a portion of the back off times of half duplex NIC 118. Therefore, half duplex NIC 118 potentially waits for a shorter amount of time before attempting to retransmit a particular data packet as compared to half duplex NICs 222–234. In this fashion, back off time restrictor circuit 140 causes half duplex NIC 118 to have transmission priority over half duplex NICs 222–234 within Ethernet network 120.

Generally, when half duplex NIC 118 detects a collision of a data packet that it is transmitting, back off time restrictor circuit 140 receives a random number signal 310 which is stored within a random number register 302. Additionally, a mask signal 312 is stored within a mask register 304. The mask signal 312 and the random number signal 310 are input into a logical AND gate 306, where they are bit-wise ANDed together to produce a masked number signal 314. Within the present embodiment, the function of mask signal 312 is to mask or restrict the value of random number signal 310, which results in masked number signal 314. The masked number signal 314 is stored within a masked number register 308. The restricted value represented by masked number signal 314 is subsequently used by half duplex NIC 118 to determine its back off time for the corresponding data packet collision. Therefore, by changing the value of mask signal 312, the present embodiment is able to adjust the maximum back off time limit of half duplex NIC 118.

Specifically, with reference still to FIG. 3, when half duplex NIC 118 detects a collision of a data packet that it is transmitting, a random number generator function (not shown) produces random number signal 310. Within the present embodiment, the determination of the value of random number signal 310 by the random number generator function complies with the 802.3 specification of the Institute of Electrical and Electronics Engineers (IEEE). Specifically, X is equal to the number of collisions of the data packet while Y is equal to the value of X or 10, whichever has a smaller value. The random number generator function then determines the value of random number signal 310 by randomly choosing an integer value N which is within the value range of 1 to 2^Y, inclusively. For example, if X is equal to the value of 5, then Y is equal to the value of 5, since 5 has a smaller value than 10. The random number generator function then determines the value of random number signal 310 by randomly choosing the integer value of 15, which is within the value range of 1 to 32, inclusively. It should be appreciated that determining a random number value in this fashion is part of the 802.3 specification of the IEEE, which is well known by those of ordinary skill in the art.

Within the present embodiment, the random number register 302, which is a 16 bit register, is coupled to receive the random number signal 310 from the random number generator function. Upon receiving random number signal 310, the random number register 302 temporary stores it. Furthermore, mask signal 312 is stored within mask register 304, which is also a 16 bit register. It should be appreciated that one embodiment for determining the value of mask signal 312 in accordance with the present invention is described in detail below with reference to FIG. 4. The outputs of random number register 302 and mask register 304 are coupled to inputs of AND gate 306. As such, mask signal 312 and random number signal 310 are output to AND gate 306, where they are bit-wise ANDed together to produce masked number signal 314. It should be understood that the determined length of the back off time of half duplex NIC 118 is directly related to the value of masked number signal 314. Specifically, as the value of masked number signal 314 becomes smaller, the determined back off time becomes shorter. It should be further appreciated that mask signal 312 of the present embodiment is specifically used to mask part or all of the bits of random number signal 310 in order to produce masked number signal 314. As such, mask signal 312 is used by the present embodiment to establish a maximum value limit for the resulting masked number signal 314.

For example, in order to restrict the value of the masked number signal 314 to the value of the 4 least significant bits of random number signal 310, the 12 most significant bits of mask signal 312 are set equal to zero while its 4 least significant bits are set equal to 1. In this manner, AND gate 306 produces a masked number signal 314 equal to the value of the 4 least significant bits of random number signal 310. As such, mask signal 312 is used by the present embodiment to mask out the 12 most significant bits of random number signal 310 in order to produce masked number signal 314. Within another example, if all 16 bits of mask signal 312 are equal to zero, AND gate 306 produces a masked number signal 314 having a value equal to zero. Therefore, it is appreciated that the mask signal 312 of the present embodiment can be utilized to restrict the value of the masked number signal 314 to the value of any number of bits of random number signal 310.

Referring still to FIG. 3, the outputs of AND gate 306 are coupled to inputs of masked number register 308. As such, masked number signal 314 is output by AND gate 306 to masked number register 308, which is a 16 bit register. Masked number register 308 outputs the restricted value represented by masked number signal 314 to half duplex NIC 118. In order to determine the length of its back off time, half duplex NIC 118 of the present embodiment multiples the value of masked number signal 314 by 512 clock cycles. The resulting number of clock cycles is the determined length of time for the back off time of half duplex NIC 118. As such, by changing the value of mask signal 312, the present embodiment is able to adjust the maximum back off time limit of half duplex NIC 118.

With reference now to FIG. 4, a flowchart 400 of steps performed in accordance with one embodiment of the present invention for dynamically adjusting the value of mask signal 312 of FIG. 3 is shown. It is appreciated that as the value of mask signal 312 is adjusted by the present embodiment, the maximum back off time limit of half duplex NIC 118 is adjusted in order to provide it transmission priority over Ethernet network 120. Flowchart 400 includes processes of the present invention which, in one embodiment, are carried out by a processor and electrical components under the control of computer readable and computer executable instructions. The computer readable and computer executable instructions reside, for example, in data storage features such a computer usable volatile memory unit 104 and/or computer usable non-volatile memory unit 106 of FIG. 1. Although specific steps are disclosed in flowchart 400 of FIG. 4, such steps are exemplary. That is, the present invention is well suited to performing various other steps or variations of the steps recited in FIG. 4.

At step 402, in one embodiment of the present invention, a collision counter is initialized to the value of zero. It should be appreciated that the collision counter of the present embodiment is used to determine the amount of collisions a data packet experiences before being transmitted over Ethernet network 120. It should be further appreciated that the collision counter of the present embodiment can be implemented in software or hardware (e.g., statistic register).

In step 404 of FIG. 4, the present embodiment determines an average number of data packet collisions experienced by half duplex NIC 118. Specifically, for a predetermined number of data packets, the present embodiment determines the amount of collisions each data packet experiences before finally being transmitted over Ethernet network 120 by half duplex NIC 118. It is appreciated that the present embodiment utilizes the collision counter initialized in step 402 in order to keep track of the collisions of each data packet. As part of step 404, the present embodiment totals the amount of collisions each data packet experienced thereby resulting in a data packet collision total. The data packet collision total is divided by the predetermined number of data packets as part of step 404, thereby resulting in an average number of data packet collisions experienced by half duplex NIC 118. It should be appreciated that the determination of an average number of data packet collisions experienced by half duplex NIC 118 of the present embodiment can be performed in a variety of ways.

At step 406, the present embodiment determines whether the average number of data packet collisions experienced by half duplex NIC 118 is within a predetermined value range. For example, the predetermined value range of the present embodiment could be equal to the values of 3 to 5, inclusively. It is appreciated that the predetermined value range of the present embodiment is well suited to be equal to many different values. At step 406, if the average number of data packet collisions experienced by half duplex NIC 118 is within the predetermined value range, the present embodiment proceeds to step 414. If the average number of data packet collisions experienced by half duplex NIC 118 is not within the predetermined value range during step 406, the present embodiment proceeds to step 408.

In step 408 of FIG. 4, the present embodiment determines whether the average number of data packet collisions experienced by half duplex NIC 118 is greater than the predetermined value range. If the average number of data packet collisions experienced by half duplex NIC 118 is greater than the predetermined value range during step 408, the present embodiment proceeds to step 412. At step 408, if the average number of data packet collisions experienced by half duplex NIC 118 is not greater than the predetermined value range, the present embodiment proceeds to step 410.

At step 410, the present embodiment increases the stored value of mask signal 312. For example, given the 12 most significant bits of the stored value of mask signal 312 are equal to zero and its 4 least significant bits are equal to 1. At step 410, the present embodiment sets the 11 most significant bits of the stored value of mask signal 312 equal to zero and sets its 5 least significant bits equal to 1. In this manner, the present embodiment increases the stored value of mask signal 312. It should be appreciated that step 410 of the present embodiment can be performed in a variety of ways in accordance with the present invention.

In step 412 of FIG. 4, the present embodiment decreases the stored value of mask signal 312. For example, given the 12 most significant bits of the stored value of mask signal 312 are equal to zero and its 4 least significant bits are equal to 1. At step 412, the present embodiment sets the 13 most significant bits of the stored value of mask signal 312 equal to zero and sets its 3 least significant bits equal to 1. In this manner, the present embodiment decreases the stored value of mask signal 312. It should be appreciated that step 412 of the present embodiment can be performed in a variety of ways in accordance with the present invention.

At step 414, the present embodiment outputs the stored value of mask signal 312 to mask register 304 of FIG. 3, as previously described above. After completing step 408, the present embodiment of flowchart 400 is exited. As such, the present embodiment of flowchart 400 dynamically adjusts mask signal 312 which results in the dynamic adjustment of the maximum back off time limit of half duplex NIC 118. As such, the present embodiment provides half duplex NIC 118 transmission priority over Ethernet network 120.

Thus, embodiments of the present invention provide a method and system for providing transmission priority to a half duplex Network Interface Card (NIC) of a particular computer station (e.g., file server) which is coupled to a congested Ethernet network. Furthermore, embodiments of the present invention provide a method and system which achieves the above accomplishment and also provides a method and system to dynamically adjust the maximum back off time of a half duplex NIC coupled to an Ethernet network.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

What is claimed is:

1. A method for providing priority to a peripheral component in a congested network, said method comprising:

(a) determining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over a network;

(b) detecting a collision of a second data packet during transmission of said second data packet by said peripheral component coupled to said network;

(c) determining a back off time, wherein said back off time is substantially equal to or less than said maximum back off time limit; and

(d) causing said peripheral component to wait said back off time before trying to retransmit said second data packet over said network.

2. The method as described in claim 1, wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit increases in value as said number of collisions decreases in value.

3. The method as described in claim 1, wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network,

wherein said maximum back off time limit decreases in value as said number of collisions increases in value.

4. The method as described in claim 1, wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit is based on a number generated by a random number generator function.

5. The method as described in claim 1, wherein (b) comprises:

detecting said collision of said second data packet during transmission of said second data packet by said peripheral component coupled to said network, wherein said peripheral component comprises a Network Interface Card (NIC).

6. The method as described in claim 1, wherein (b) comprises:

detecting said collision of said second data packet during transmission of said second data packet by said peripheral component coupled to said network, wherein said network comprises an Ethernet network.

7. The method as described in claim 1, wherein (c) comprises:

determining said back off time, wherein said back off time is associated with an Ethernet network.

8. A computer system comprising:

a processor;

an addressable data bus coupled to said processor;

a computer usable memory coupled to communicate with said processor for performing a method for providing priority to a peripheral component coupled to a network, said method comprising:

(a) determining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over said network;

(b) detecting a collision of a second data packet during transmission of said second data packet by said peripheral component coupled to said network; and

(c) ascertaining a back off time, wherein said back off time is substantially equal to or less than said maximum back off time limit.

9. The computer system as described in claim 8 wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit increases in value as said number of collisions decreases in value.

10. The computer system as described in claim 8 wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit decreases in value as said number of collisions increases in value.

11. The computer system as described in claim 8 wherein (a) comprises:

determining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit is based on a number generated by a random number generator function.

12. The computer system as described in claim 8 wherein said peripheral component comprises a Network Interface Card (NIC).

13. The computer system as described in claim 8 wherein said network comprises an Ethernet network.

14. The computer system as described in claim 8 wherein (c) comprises:

ascertaining said back off time, wherein said back off time is associated with an Ethernet network.

15. A computer readable medium having computer readable code embodied therein for enabling a peripheral component coupled to a network to gain priority, comprising:

(a) ascertaining a maximum back off time limit based on a number of collisions a first data packet encounters before being transmitted over said network;

(b) detecting a collision of a second data packet during transmission of said second data packet by said peripheral component coupled to said network;

(c) ascertaining a back off time, wherein said back off time is substantially equal to or less than said maximum back off time limit; and

(d) causing said peripheral component to wait said back off time before trying to retransmit said second data packet over said network.

16. The computer readable medium as described in claim 15, wherein (a) comprises:

ascertaining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit increases in value as said number of collisions decreases in value.

17. The computer readable medium as described in claim 15, wherein (a) comprises:

ascertaining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit decreases in value as said number of collisions increases in value.

18. The computer readable medium as described in claim 15, wherein (a) comprises:

ascertaining said maximum back off time limit based on said number of collisions said first data packet encounters before being transmitted over said network, wherein said maximum back off time limit is based on a number generated by a random number generator function.

19. The computer readable medium as described in claim 15, wherein (b) comprises:

detecting said collision of said second data packet during transmission of said second data packet by said peripheral component coupled to said network, wherein said peripheral component comprises a Network Interface Card (NIC).

20. The computer readable medium as described in claim 15, wherein (b) comprises:

detecting said collision of said second data packet during transmission of said second data packet by said peripheral component coupled to said network, wherein said network comprises an Ethernet network.

21. The computer readable medium as described in claim 15, wherein (c) comprises:

ascertaining said back off time, wherein said back off time is associated with an Ethernet network.

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